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The Infrastructure of Academic Research

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This paper is intended to stimulate discussion of the issues surrounding the erosion of the infrastructure supporting research in Canadian universities. Although it has been written from the perspective of a natural scientist, it is intended to apply to science in a wider sense which includes the social sciences and humanities. While the paper makes some assertions unsupported by data, the author believes these statements to be supportable. The paper first seeks to define the infrastructure of research, and then explores the factors which are contributing to an accelerating erosion of the infrastructure.

It is not easy to arrive at a simple statement which captures all that is customarily implied by infrastructure for research. Infrastructure, however, has certain characteristics. First, of course, it is **essential**: without the infrastructure, the research in question could not proceed, even if a grant were awarded to do the research. Infrastructure costs

Highlights

- The fact that university infrastructure has eroded — and is continuing to erode — is all too obvious when you visit a campus. Equipment is aging, facilities deteriorating, and there are fewer skilled personnel who can maintain and operate the much-needed research tools.
- Research infrastructure includes many, often overlooked, elements. Examples include:
  - Administrative overheads: the cost of preparing and negotiating contracts, administering research contracts, secretarial support, the cost of technology transfer, and the cost of ensuring that increasingly complex government regulations are met.
  - Facilities and equipment, including their operation and maintenance: animal care facilities, workshops, computer-based communications, and access to databases. Libraries are also an essential part of the research infrastructure.
  - Research personnel: technicians, computer programmers, cartographers. Also includes professor/researchers themselves, who spend about 40 to 50 per cent of their normal work week on research, as well as work done by undergraduate, graduate and postdoctoral students.
- Infrastructure is eroding, not only because there is less and less funding for it, but also because new ways of conducting research bring new costs.
- The increasing move to commercialize university research, while beneficial to all, also adds costs to the research infrastructure.
- The biggest — and almost invisible — erosion of infrastructure has occurred around professorial time. Universities have reduced the size of their work force, and professors are devoting more of their time to clerical and secretarial tasks. Teaching loads have increased, leaving less time for research.

Our institutions are aging. The physical infrastructure to support the high technological demands of research in the pure and applied sciences are very expensive. Similarly, the humanities and social sciences have an equally high demand for the newest in communication technology if they are to remain competitive.

— Bernard H. Bressler, vice president (research), The University of British Columbia.

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are **continuing**: maintenance of the infrastructure is essential if the research enterprise is to capitalise on funding opportunities. Infrastructure costs are often **large** in relation to the so-called direct costs of a piece of research: while it might be possible to identify a component of infrastructure costs assignable to a specific research project, this has not been the custom in Canadian universities, which have sought to provide the infrastructure broadly to all fields of science from their normal operating budgets. The Canadian Association of University Business Officers developed a model in the 1980s which attempted to arrive at an estimate of the size of the indirect costs in the context of fixing an agreed overhead rate for federal research contracts. The most recent document[1] demonstrates the complexity of the task, indicates that costs vary with discipline and institution, and concludes that the appropriate overhead rate is about 40 per cent of the total direct costs (including as a direct cost the costs of the principal investigator's time, normally donated by the institution). But this 40 per cent figure is to some degree a negotiated rate, and may not include all elements of infrastructure.

While it is difficult to codify these essential, continuing and large costs of maintaining the research enterprise in Canadian universities, some general categories of costs can be identified.

Administrative Overheads have always been identified by universities as costs attributable to research. These include the Offices of Research Administration, which oversee the often complex web of regulations surrounding research grants,

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negotiate and administer research contracts and provide a variety of other services. Universities may incur significant costs in preparing bids for participation in major recent enterprises such as the Networks of Centres of Excellence. The accounting departments of most universities customarily operate a separate research accounting department. Personnel and payroll offices incur extra costs. The administration of increasingly complex regulations surrounding safety in the workplace and waste disposal requires additional personnel. Secretarial support for the researcher is a part of these hidden costs. The costs of transferring knowledge or technology to the community, whether it be the private sector, or various levels of government (which often rely on university research as underpinning for policy development), are significant.

Facilities and Equipment have been provided in the past by universities and, even when major pieces of equipment or major facilities have been provided by the granting councils, the operation and maintenance of such facilities is seen to be a responsibility of the universities. Facilities ranging from electron microscopes to telescopes or mass spectrometers all require ongoing maintenance, frequently by skilled personnel. Animal care facilities for the life sciences, workshops for the construction of equipment, photographic and drafting services in

Many graduate and undergraduate students are losing out on valuable training and experience because investigators no longer have sufficient funds to hire them throughout the term or even in the summer. This affects our ability to attract top students.

— W.A. Bridger, vice-president (research), The University of Western Ontario

support of research publication are all examples of research infrastructure costs. Increasingly, computer-based communications technologies (e-mail and more sophisticated methods of data transfer) are becoming part of the everyday infrastructure in all disciplines: access to computers and the Internet is now essential for nearly all university researchers. These enhanced communication technologies have rendered increases in bandwidth mandatory. Access to large databases (such as those of Statistics Canada) is now seen as part of the infrastructure in the social sciences.

A special case of facilities and equipment is represented by the start-up costs of employing a new faculty member. These are most obvious in the natural sciences, where the costs of providing a new laboratory with the normal items of equipment essential to making even an application for funding will customarily exceed $300,000, but there are similar costs in other disciplines.

Although **Libraries** might be considered as facilities, they probably deserve a category of their own. It is clear that libraries represent a very large component of the infrastructure for research. It is also clear that the role of libraries is changing and that the future is unclear. Traditionally, the library has served as a repository for print-based materials which scholars, including students, could access as the need arose. Increasingly, however, the library is becoming an access point to research materials which may be housed at a distant library or which may be stored electronically. While the "virtual library" may be many years in the future, a growing proportion of library resources is devoted to the acquisition of and/or access to non-print materials.

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There has been a dramatic increase in electronic publications, including many scholarly journals. The impact of electronic publishing of scholarly journals is uncertain, particularly in terms of costs. The necessity to provide access to these developments in the face of shrinking resources has made it impossible for most libraries to maintain adequate research collections in any but a very few fields. As a consequence, rapid, reliable and low cost access to a network of libraries is now essential for research. Thus, libraries, already constrained by budget, must increasingly deal with issues such as bandwidth and electronic infrastructure.

The Personnel of Research represent an important category of infrastructure. Obviously, the skilled personnel who maintain the facilities or provide the services outlined above, from electronics technicians or computer programmers to cartographers, represent an obvious infrastructure resource. But there are other categories of personnel as well. Perhaps the most important and overlooked category is the professor/ researcher. A component of the salary of every active researcher in the professoriate is assignable to the research infrastructure. There have been attempts to document that in the past, but these estimates have varied widely. Part of

Inevitably, the day will arrive when researchers have no other choice but to fund — either from their own grants or from group grants — the equipment and facilities that universities can no longer provide.

— Maurice St-Jacques, vice-rector for research and planning, Université de Montréal.

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the difficulty lies in the inability to dissect neatly the various activities of the professoriate. It is pretty clear that when a professor is lecturing to a class of 200 or more, he or she is engaged in teaching. But when those same professors are supervising the thesis research of an undergraduate honors student, or employing an undergraduate as a laboratory assistant, are they teaching or doing research? Some of the difficulties have been recognized in a consultants report on the methodology to be used in examining Canadian university research[1]. Nevertheless, the author's own experience suggests that on average something like 40 to 50 per cent of the normal work week is spent on activities related to research. Moreover, it is important to understand that the average professor/ researcher puts in very long days indeed. The author's perception of a normal work week of 60 to 70 hours for active researchers accords well with estimates of 50 to 60 hours developed by the Ontario Council of University Affairs[2]. If that experience is generalised, this is probably the largest single component of the infrastructure underpinning research in Canadian universities.

The professoriate is increasingly supplemented by a category of quasi-independent professional researchers who are making careers in academic research, paid from contracts and grants negotiated by the professoriate. While their salary costs are met as part of the direct costs of grants or contracts, the existence of this cadre of researchers now represents part of the infrastructure. Their maintenance between contracts or grants should be seen as a legitimate infrastructure cost. As our capacity to maintain these professional researchers erodes, they are being lost to the system, either by emigrating to another country or switching to a career other than research.

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The future generations of researchers also represent part of the infrastructure of research. Unless that element of the infrastructure, represented by the best of the undergraduates, graduate students and post-doctoral fellows, is maintained, our future capacity to undertake research in universities will be compromised. Most researchers in the natural sciences got their first taste of research as undergraduate research assistants, typically in a university laboratory. Many departments require honors students to undertake a research thesis. At least part of our capacity to continue to support such enterprises is bound up in the time that professors can devote to such very demanding activities. As the funds available to universities shrink, and as the requirement for professors to deal with greater numbers of undergraduate students increases, there will be less and less time to provide the individual attention that a genuine research experience for undergraduates requires.

Graduate students and professors in engineering do not now embark on experiment-based research to anywhere near the same degree that they did in the past. Instead, much more computer-based research using numerical methods is being conducted. This raises the question as to how far an applied science such as engineering can afford to go in terms of predictions and designs that are not based on experimental evidence.

— Terrence P. Hogan, vice-president (research and external programs), The University of Manitoba.

Factors contributing to the erosion of the infrastructure

For any university researcher who has been in the system for several years, the fact that the infrastructure has been eroded, and continues to erode, is all too obvious. While equipment is aging, the principal erosion has occurred around professorial time. Universities have been forced to reduce the size of the work force which directly supports the academic enterprise, partly because resources are shrinking, but also because employment equity, safety in the workplace legislation and other government regulations have required an increase in managerial staff. As a result, a greater proportion of the clerical and secretarial tasks have been downloaded onto the professoriate. Rather than document the erosion, however, this paper seeks to identify some of the factors which have contributed to, or are likely to accelerate, the erosion.

Universities and other agencies have sought, where possible, to transfer costs which had formerly been treated as infrastructure costs, to the direct costs of research grants. These practices vary from institution to institution, but among the costs which are involved are: animal care costs, the costs of operating facilities such as electron microscopes, waste disposal, and labor costs for workshops. It is important to note that these do not involve costs normally regarded as administrative overhead, and it is equally important to acknowledge that these charges are now regarded as legitimate by the granting agencies. But these costs were formerly partially or wholly covered as part of the infrastructure costs. It is also important to note that research grants are not intended to cover the full costs of research, as contracts are. These and other costs are legitimate charges against contracts, but it may not be appropriate that grants support such new charges when the funds available to the granting councils are decreasing.

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Universities are not the only organizations which have transferred infrastructure costs to the direct costs. For example, Statistics Canada, in the face of its own internal financial costs, has required payment for access to its databases by university researchers. Fisheries and Oceans Canada for many years supplied ship time for oceanographic research by university-based scientists, but abruptly altered that stance to one of full cost-recovery, even for research programs which were already in progress at the time.

The continued reduction in transfers to the granting councils in recent years has resulted in the cancellation of several programs which support the infrastructure. For example the cancellation by Industry Canada of the program of Canada Scholarships and by the Natural Sciences and Engineering Research Council of the program of summer research awards have together made it more difficult for the best of our undergraduates to obtain hands-on research experience. The students who benefitted financially from the Canada Scholarships are no longer able to accept relatively low-paying summer jobs in university labs

Small universities are in a bind: granting councils are shifting emphasis to collaborative projects between and among institutions, disciplines and various government and non-government sectors, but the small institution simply does not have the infrastructure to develop proposals for these projects. The significant cuts to general research grants mean smaller universities lack funding even to participate with larger institutions, because most require some upfront expenditures for travel, communication, etc. at the conceptual stage of a joint proposal.

— Alison McNeill-Horden, director of planning, Brandon University

and are forced to look for employment unrelated to their university interests. An important part of the early training of students in science has been represented by employment in university research labs in the summer. Now, however, because of the other demands on research grants, the slack is unlikely to be taken up by research grants. A rapid and informal survey suggests that some students are still getting that training, but these are volunteer workers, suggesting that only those students from relatively privileged backgrounds are likely to take part in such training. There will be socially regressive effects if the trend continues.

The cancellation of NSERC's University Research Fellowships and Women's Faculty Award Programs may result in a reduced rate of hiring to replace retirees, as universities face the stark realities of reduced operating budgets. Moreover, the demand for equipment continues to increase, and an evaluation of the NSERC Equipment Grants Program[1] in 1990 demonstrated the decay during the previous 10 years. In 1981, it was estimated that 17 per cent of equipment would soon become obsolete: in 1990, the figure was 28 per cent. In 1981, 61 per cent of equipment would be usable for 5 years, and by 1990 the figure was 43 per cent. About 40 per cent of the equipment was purchased from university funds, and since 1990 there has been further erosion in both NSERC and university funding.

But the greatest threat to the research infrastructure of the universities is represented by the restructuring which the universities now face as the result of reductions in provincial funding of universities, reductions which are exacerbated by changes of federal transfer payments in support of postsecondary education. In this restructuring, the public and decision-makers alike recognize only the teaching function of universities and fail to understand the crucial synergy between teaching and research or the pivotal role of university-based basic research in the national research enterprise.

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In the face of previous cuts, universities have reduced the support services available to professors. In addition, as a result of reduced resources, teaching loads are beginning to increase. In the author's department, for example, we have recently agreed to increase our departmental teaching load by about 25 per cent in response to unprecedented demand for undergraduate courses and shrinking resources. For most professors, this has reduced the amount of time which they can devote to research. Thus the single most important element of the research infrastructure, and certainly the element with the greatest dollar cost attached to it, is gradually eroding in a way which is almost invisible.

There is further consequence of the reduction in funding. As part of the response to reduced transfer payments from the provinces, universities are increasing sharply the fees charged to students, including graduate students.

Our major problem at McGill is that our plant is old, we have a quarter of a billion dollars worth of deferred maintenance. When the roof threatens to cave in, we are limited as to our ability to take care of capital expenses for research.

— Pierre R. Bélanger, vice-principal (research) and dean, faculty of graduate studies and research, McGill University.

In the natural sciences, research students receive stipends from the research grants of their supervisors, and the increase in fees will most likely lead to pressure for increased stipends. In turn, an increase in stipends will almost certainly mean a reduction in numbers of graduate students in the natural sciences, although it is too early for any trend to be clear. In a sense, this represents a further example of the infrastructure costs being transferred as direct costs to research grants.

Each of these factors produces small incremental changes — changes, moreover, which are often invisible. The total effect will not be felt for some time, perhaps as much as a generation in the case of future researchers. But if Canada is to retain its place in a highly competitive knowledge based society, it is essential that the infrastructure which supports the principal engine driving the growth of knowledge be maintained and strengthened as we enter the 21st century.

Endnotes

1. Brochu, Mireille (1996) Indirect Costs on Federal Research Contracts to Universities. (A discussion paper prepared for CAURA, AUCC and Industry Canada.

2. ARA Consulting Group (1993). The State of Research in Canadian Universities Methodology Design Study. Prepared for ISTC.

3. Ontario Council on University Affairs (1994) The Structure of Academic Work.

4. Natural Sciences and Engineering Research Council (1990) NSERC Equipment Grant Program Evaluation.

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— Allan Tupper, associate vice-president (government relations), University of Alberta.

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